Mobile x-ray Inspection equipment for Military Force Protection

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Introduction and Statement of problem.

As the role of the United States Military continues to change, there is an increased need to protect service members, their dependents and civilian employees from acts of terrorism. Of primary concern are those acts that involve car bombs and small arms attacks. An additional dimension to this challenging problem is that the military forces must be deployed on short notice. Therefore, technology that is envisioned to counter these potential acts of terrorism must also be deployable. Especially during times of heightened threat level it is useful to have the capability to deploy additional security measures to augment the permanent security activities. A sample (and fictitious) airbase scenario is shown in figure 1 below.

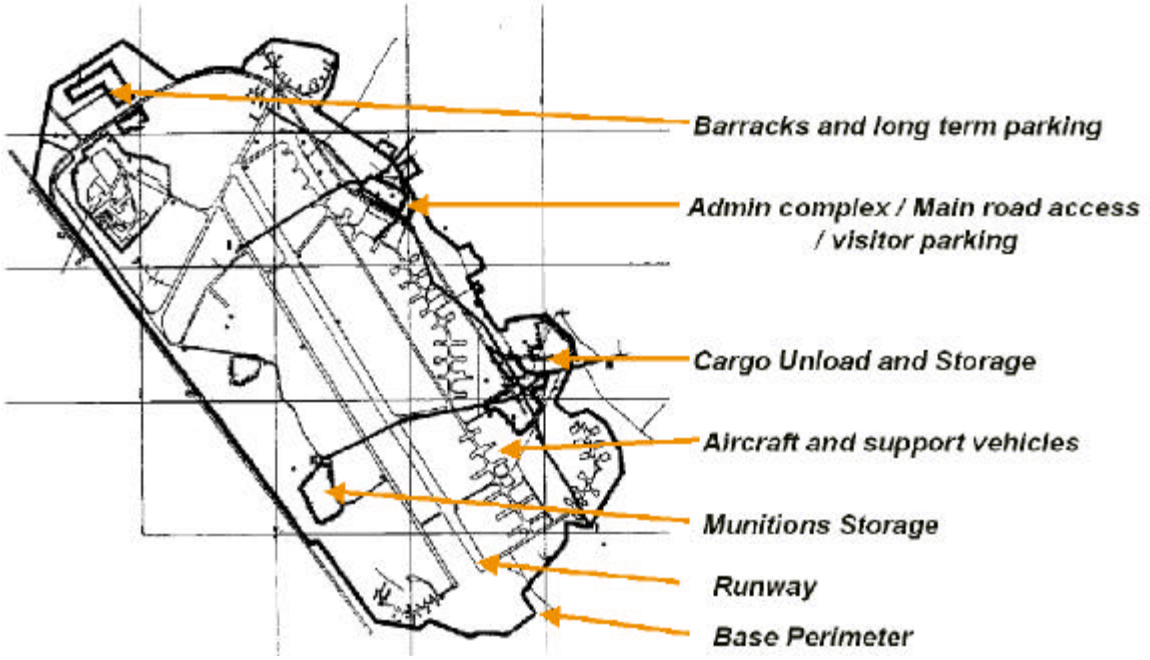

Figure 1. A sample Military Force Protection scenario : airbase.

Normal operations include:

- Temporary storage of incoming and outbound cargo.
- Road traffic of cargo and visitors.
- Transport aircraft operations.
- Strike aircraft operations.
- Munitions storage and re-supply operations.
- Housing of transitory Base personnel and dependants.

AS&E's response

American Science and Engineering has fielded several x-ray based systems that can be used to protect Military Forces. This paper focuses on MobileSearch™and IsoSearch ™ systems. These systems are extremely mobile and flexible x-ray inspection systems capable of inspecting large packages, vehicles and shipping containers to find car bombs, small arms, contraband and hidden passengers.

System Technology

All AS&E products employ a patented "flying spot" x-ray beam technology (see Fig 2).

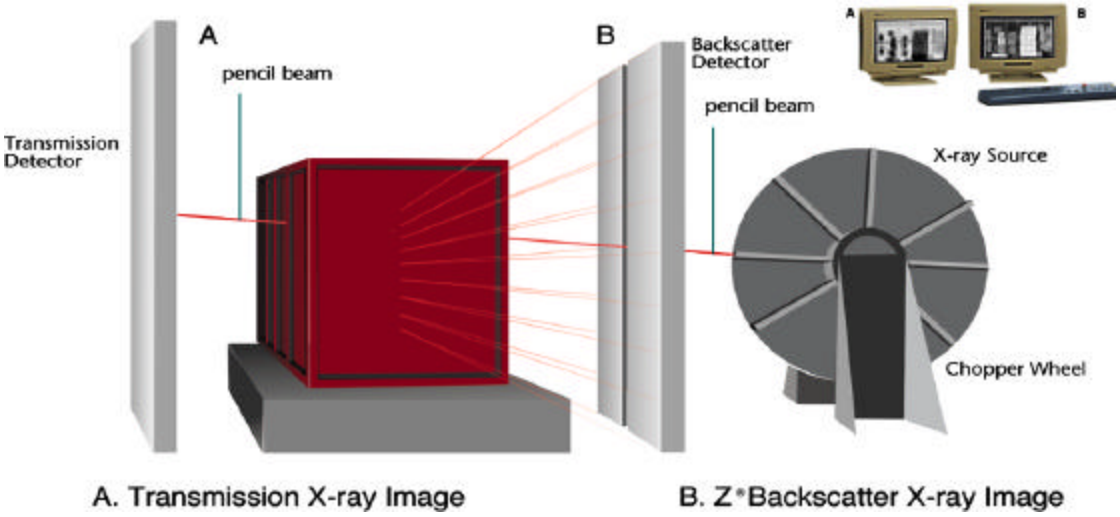

Figure 2. AS&E flying spot x-ray technology, Backscatter and Transmission images.

This minimizes the radiation dose delivered to the target and operations staff. All AS&E products are certified as cabinet systems per CDRH 21 CFR Section 1020.40. This minimizes restrictions on the movements of operators, minimizes exposure to the general public, and minimizes the training and protective equipment required by operations staff. MobileSearch and IsoSearch employ 450keV x-ray sources -- an energy that is low enough to meet FDA requirements for the inspection of foodstuffs without labeling. Transmission and Backscatter detector systems are used to image both high Z and low Z elements, respectively. This allows the same system to quickly identify plastics, explosives and drugs as well as small arms, contraband and cargo discrepancies.

Characteristics of these systems.

MobileSearch is used to patrol threat areas and inspect vehicles and their contents. It houses all components within a truck chassis, is totally self-contained and can be transported by C-17 aircraft (see Figure 3).

Figure 3 MobileSearch on patrol.

Figure 4 : AS&E MobileSearch scanning in Bahrain earlier this year.

MobileSearch utilizes one 450keV x-ray source. The Transmission x-ray detector is mounted on a hydraulic boom assembly that is deployed only when imaging (see Fig 4). Relative motion between the x-ray source and the target is achieved using a precision drive that moves the MobileSearch system past the target.

IsoSearch (see Figure 5 below) is a relocateable system that is used to inspect vehicles, cargo containers and their contents at secure checkpoints.

Figure 5. IsoSearch components.

IsoSearch houses all scanning components in two 40ft ISO containers that can be shipped using conventional shipping methods (truck, air, containership). Optional transport systems are shipped separately. IsoSearch utilizes two 450keV x-ray sources. Transmission detectors are mounted externally to the containers when imaging, and relative motion of the target vehicle is achieved using an Automated Guided Vehicle (AGV) and dolly (see Fig. 6 below).


Figure 6. IsoSearch in operation.

Typical Images

Figures 7,8,9,and 10 are representative of the capabilities of IsoSearch and MobileSearch systems.

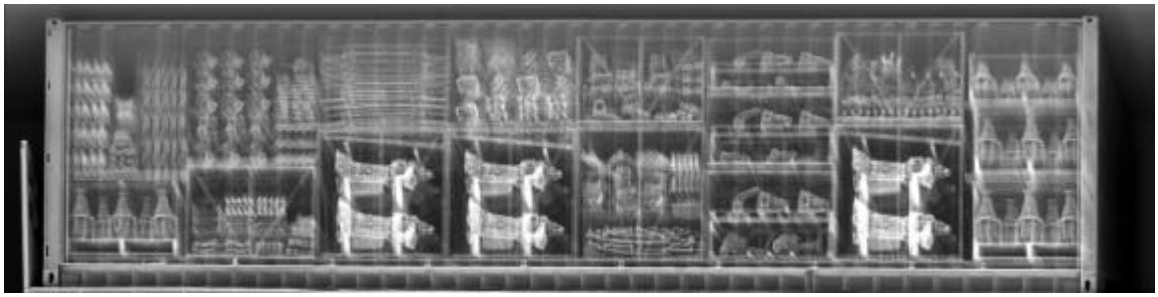
Figure 7 : AS&E IsoSearch BackScatter Image of 60ft ISO Container.
Note that BackScatter aids recognition of cargo type as well as organic materials.

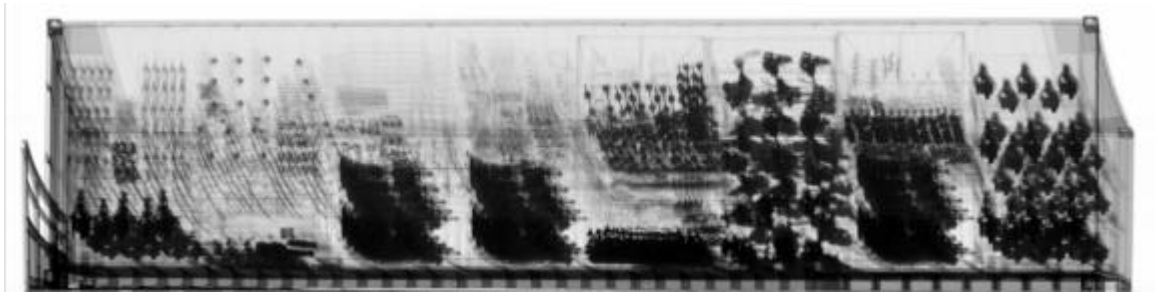
Figure 8 : AS&E IsoSearch Transmission Image of a 60ft ISO Container.
Note that Transmission information shows distribution of load, density and structure.

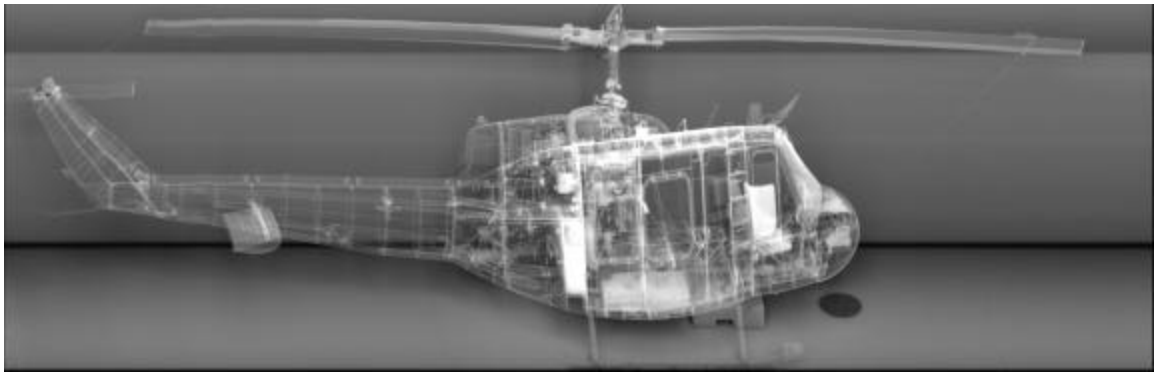

Figure 9 : AS&E MobileSearch Backscatter Image.
Note that vehicles can be imaged in Backscatter only for inspection purposes.

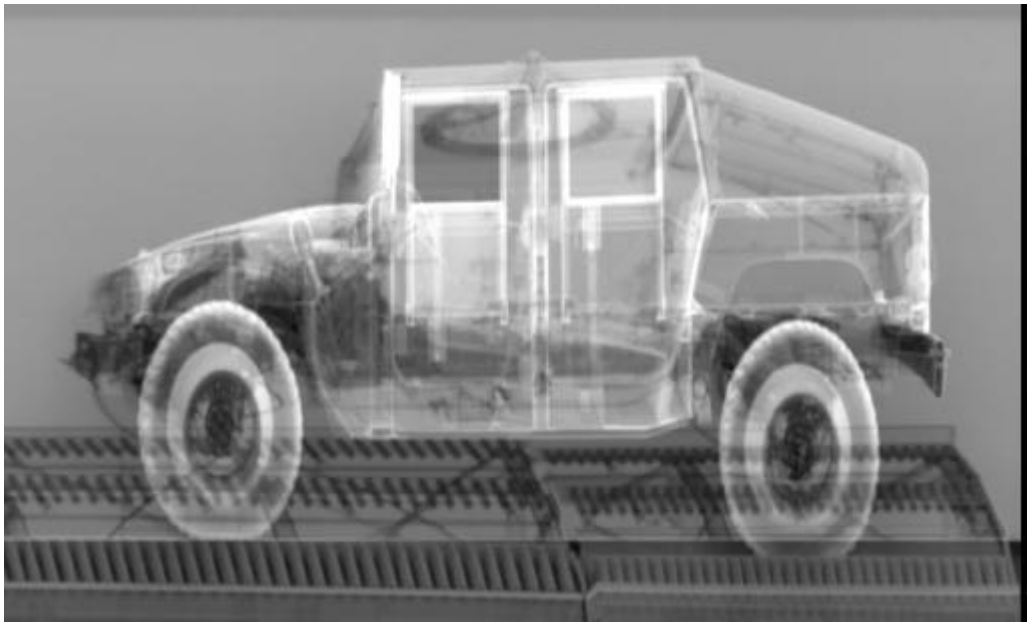

Figure 10 : AS&E MobileSearch Transmission Enhanced Backscatter Image.
Note that Backscatter and Transmission data sets can be manipulated offline and displayed.

Application of these systems in deployment scenarios worldwide.

Worldwide deployment of MobileSearch and IsoSearch can be achieved using conventional shipping methods at short notice.

A recommended crew of 3 operate MobileSearch. The system is capable of commencing scanning operations immediately upon arrival at the threat area . The crew is in contact with each other using radio communications. The spotter directs traffic and sets up a scanning run. The driver controls the MobileSearch truck. The image analyst commands the start of scanning operations, monitors the x-ray tunnel using surveillance cameras,

observes the system status and image displays. Random traffic stops or lines of vehicles can be scanned at will.
MobileSearch displays the Transmission and Backscatter information during scanning. Hidden compartments, small arms, explosives and contraband are quickly identified by a trained analyst. Random patrolling of threat regions can also be achieved, even scanning of parked vehicles in an unobtrusive "Backscatter-only" mode (boom not deployed). MobileSearch has been tested by several government agencies and has recently completed trials with the Navy in Bahrain. Over 500 scans have been performed over an 18 day period, at an operational base.

IsoSearch, a relocateable system capable of scanning cargoes from both sides, can be set up in 3 days at the target site before scanning operations can commence. The suggested crew of 3 consists of a load operator, unload operator and an image analyst. The load operator directs target vehicles onto the AGV's dolly transport and initiates scanning. The image analyst observes system status and the 4 image displays. The unload operator unloads the target vehicle after it has been scanned and returns the AGV. During scanning operations the Backscatter and Transmission information can be manipulated in real-time by the analyst. Additional database and image processing features to support container tracking and customer profiling interfaces are included as part of the IsoSearch post processing.

Advanced Features and their application to force protection :

Networking :
The deployed force protection x-ray equipment is enhanced when all units are able to quickly communicate status and scan results to all other deployed components. A central x-ray command and control center could house wireless communications, archiving, remote image analysis and interface with the base communications services.
The standard MobileSearch is equipped with local area communications. Temporary storage of scanned images to local hard disk is also possible for subsequent upload to permanent archive media. IsoSearch is equipped with Ethernet and ready for integration into an existing local area network.

Database :
MobileSearch includes a proprietary format standalone database for archival, searching and retrieval of recorded information. IsoSearch contains an ODBC (Open Database Connectivity) compliant database designed for seamless integration with fleet/force security.

Image Processing :
Grayscale images are used for standard image analysis operations. Color palettes can be selected for use in IsoSearch systems. Standard image processing operations include manipulation of the Transmission and Backscatter images (zoom, pan, density expand, edge enhance, histogram equalization). Advanced algorithms can be specified and employed to enhance operator effectiveness.

Relevant Issues for Force Protection :

Imaging Performance parameters of x-ray inspection systems are typically defined as penetration, dynamic range, resolution and throughput. MobileSearch and IsoSearch offer a deployable optimal solution to these requirements, while also minimizing footprint, complexity, and setup time.

Radiation exposure risk from IsoSearch and MobileSearch is designed to be minimal. All AS&E products are declared "cabinet-safe" and held to the same radiation emission standards as television equipment. Operators, maintenance staff and any personnel scanned should understand these minimal levels.
As an example of the radiation levels encountered, here is a list of typical exposures:

MobileSearch Driver in the cab : **0.15 mR/hr. max.**
MobileSearch Image Analyst Operator in the Ops Room**: 0.15 mR/hr. max.**
Spotter / Scan Coordinator / Load operator : assuming they stand about 10 to 20 feet from the tunnel ports, as is normally the case, radiation levels would be lower than either of the above, and probably not even measureable.

Radiation Dose to Cargo : MobileSearch : **<0.1 mR**

Radiation Dose to Cargo : IsoSearch : **<0.2 mR.**

For comparison :
Average US exposure (natural + manmade) : **365mR** per year
Background Natural Radiation New York : **110mR** per year
Background Natural Radiation Colorado : **170 mR** per year
Radiation Equipment Manufacturers average exposure : **350 mR** per year
Airline Crews average exposure : **700mR** per year

Throughput of x-ray scanning systems is an issue for high volume traffic portals where any impediment to traffic flow can become a bottleneck generating delays and heightened frustration levels. Multiple systems and profiling/random selection strategies can help mitigate this concern.
IsoSearch has a maximum scan speed of 6"/second, with a throughput of 20 T.E.U. (Twenty foot ISO container Equivalent Units) or 10 trucks per hour.
MobileSearch has a maximum controlled scan speed 6.5"/second, also with a throughput of approximately 20 T.E.U's per hour. Higher throughput can be available with only slight modifications.

Training of operators, analysts and maintenance personnel is critical to assure availability and effectiveness of x-ray systems. Operator Training typically lasts two weeks. Maintenance training typically lasts three weeks and requires specialist pre-requisite skills (Electronics Technician).

A **maintenance schedule** is required to be implemented in order for x-ray systems to remain operational and effective.

Conclusion and Summary

There are very real threats to the armed forces and their equipment as their operations expand globally. AS&E has delivered a range of equipment that can be configured to combat several types of threats (transportation of small arms, explosives, contraband and personnel hidden within large cargos). MobileSearch and IsoSearch can be quickly deployed to high threat areas at short notice and commence operations. These systems integrate with and augment the permanent security operations. MobileSearch is an effective, flexible and proven tool that inspects the flow of vehicles and cargos within a threat perimeter and its surrounding area. IsoSearch offers an effective double sided view of shipping containers at predefined checkpoints within or at the force perimeter.

A sample configuration of 2 MobileSearch and 2 IsoSearch systems is shown on the fictitious airbase layout to stimulate discussion of the use of these inspection systems. (See Figure 11 below).

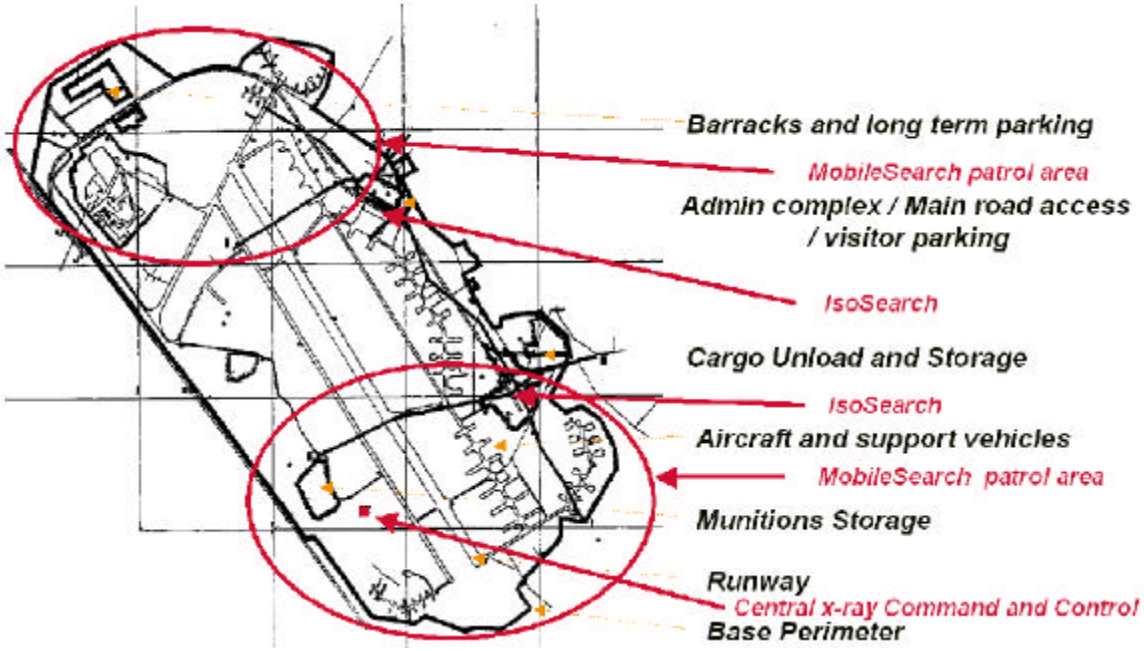

Figure 11. Hypothetical Deployment of IsoSearch and MobileSearch systems.

Besides air bases, other military applications can obviously benefit from the deployment of this additional security equipment (Materiel supply centers, Naval Ports, CCCI installations etc), particularly in times when threat conditions are heightened. The ability to perform an x-ray inspection on large objects such as trucks, cars, jeeps, shipping containers, and other incoming cargoes can significantly enhance the security of any military installation.